4. Ozone and Water Vapor

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4.1. Continuing Programs

4.1.1. Total Ozone Observations

Total ozone observations continued throughout 2000 and 2001 at the 16 stations that constitute the U.S. Dobson spectrophotometer network (Table 4.1). Of the 16 stations, CMDL personnel operated five, the National Weather Service (NWS) operated five, two are university stations, and four are foreign cooperative stations. All station instruments are either fully automated or semiautomated, except for the one at the Peruvian site. In addition, a Brewer spectrophotometer was operated on a nearly continuous basis at Boulder.

The automated system at Haute Provence, France, was finally made operational in August 2000, but was not fully reliable until December of that year. Observations at Tallahassee are continuing at Florida State University until the new NWS office is completed in January 2002, but due to personnel problems, observations are not made consistently, and the data record is not very useful. Several months of data were lost from the University of Alaska, Fairbanks, because of a failure in the 20-year-old controller unit. The replacement parts were very difficult to obtain. The dome at the Nashville (Old Hickory) site was reinsulated by a local contractor.

New computers and programs were installed at all the sites, and a new protocol was established for data transfer. Many sites transmit observational data daily, allowing preliminary ozone values to be available in near-real time.

Provisional daily total ozone amounts applicable to local apparent noon for the stations listed in Table 4.1 were archived at the World Ozone and Ultraviolet Data Centre (WOUDC), Canada, in *Ozone Data for the World*. Table 4.2 lists the monthly mean total ozone amounts measured at the stations in the network for 2000 and 2001.

Observations of total column ozone with the Dobson spectrophotometer at South Pole Observatory (SPO) with the Sun as a light source are limited to less than half of the year. Moon observations are infrequent due to adverse winter weather conditions and limited observing periods. Optical measurements with the Dobson spectrophotometer cannot be made at all during twilight periods. To better define the year-round column ozone measurements, integrated column ozone amounts from the ozonesondes are used to supplement the Dobson data during the dark and twilight months (Figure 4.1). This new data set has been analyzed with a recently developed technique [*Harris et al.*, 2001] for describing long-term column ozone changes. The decline in ozone (expressed as residuals) at SPO began in the 1970s (Figure 4.2) and has persisted through most of the record since then. Growth rates were mostly negative (Figure 4.3) throughout this period, with the largest declines in the 1970s and mid-1980s. The overall growth rate (decline) was $-8.1 \pm 0.5\%$ decade^{-1}. Even though human-produced, ozone-destroying halogen compounds have begun to decline very slowly in the stratosphere, ozone amounts have not shown any sign of recovery to their pre-1970s levels. This is expected because at the South Pole there is more than enough chlorine and bromine in the stratosphere to destroy most of the ozone in the 14- to 22-km altitude range during the spring (see section 4.1.5).

TABLE 4.1. U.S. Dobson Ozone Spectrophotometer Station Network for 2000-2001

Station	Period of Record	Instrument No.	Agency
Bismarck, North Dakota	Jan. 1, 1963-present	33	NOAA
Caribou, Maine	Jan. 1, 1963-present	34	NOAA
Wallops Is., Virginia	July 1, 1967-present	38	NOAA, NASA
SMO	Dec. 19, 1975-present	42	NOAA
Tallahassee, Florida	May 2, 1964-Nov. 30, 1989; Nov. 1, 1992-present	58	NOAA, Florida State University
Boulder, Colorado	Sept. 1, 1966-present	61	NOAA
Fairbanks, Alaska	March 6, 1984-present	63	NOAA, University of Alaska
Lauder, New Zealand	Jan. 29, 1987-present	72	NOAA, National Institute of Water and Atmospheric Research
MLO	Jan. 2, 1964-present	76	NOAA
Nashville, Tennessee	Jan. 2, 1963-present	79	NOAA
Perth, Australia	July 30, 1984-present	81	NOAA, Australian Bureau Meteorology
SPO	Nov. 17, 1961-present	82	NOAA
Haute Provence, France	Sept. 2, 1983-present	85	NOAA, Centre National de la Recherche Scientifique, University of Riems
Marcapomacocha, Peru	Feb 26, 2001-present	87	NOAA, Servicio Nacional de Meteorologia e Hidrologia
BRW	June 6, 1986-present	91	NOAA
Fresno, California/ Hanford, California	June 22, 1983-March 13, 1995; March 15, 1995-present	94	NOAA

TABLE 4.2. Provisional 2000 and 2001 Monthly Mean Total Ozone Amounts (DU)

Station	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						2000						
Bismarck, North Dakota	314	353	348	341	336	327	300	293	287	287	312	332
Caribou, Maine	–	369	356	387	359	341	335	318	304	292	280	334
Wallops Is., Virginia	328	318	339	[327]	336	[311]	[312]	302	286	279	278	303
SMO	[244]	247	246	249	252	252	257	256	260	259	259	247
Tallahassee, Florida	#	#	#	#	#	#	#	#	#	#	#	#
Boulder, Colorado	304	320	337	311	301	310	302	298	274	273	282	302
Fairbanks, Alaska	–	–	391	393	389	336	326	296	290	339	[339]	–
Lauder, New Zealand	272	259	253	272	279	303	319	332	362	364	329	285
MLO	258	267	273	288	278	271	265	264	254	254	251	238
Nashville, Tennessee	308	309	305	318	313	298	301	294	281	264	264	293
Perth, Australia	276	250	266	269	282	294	311	314	320	294	274	276
SPO	270	267	[246]	[248]	[237]	–	[231]	[226]	–	186	287	322
Haute Provence, France	322	–	–	–	–	–	–	–	[295]	292	285	295
Marcapomacocha, Peru	–	[262]	254	[249]	247	245	243	259	262	258	254	254
BRW	–	–	[403]	396	390	335	[314]	287	290	[285]	–	–
Hanford, California	290	322	318	299	305	306	303	298	282	280	273	276
						2001						
Bismarck, North Dakota	329	381	371	380	–	[296]	299	292	282	294	282	318
Caribou, Maine	[342]	[365]	[394]	[402]	[346]	[325]	348	[307]	–	–	–	–
Wallops Is., Virginia	323	297	348	342	344	317	315	308	285	[293]	275	267
SMO	246	248	242	244	243	239	238	245	253	259	267	–
Tallahassee, Florida	#	#	#	#	#	#	#	#	#	#	#	–
Boulder, Colorado	305	335	330	330	328	314	297	290	270	279	276	296
Fairbanks, Alaska	–	[410]	417	390	–	–	–	309	311	330	[321]	–
Lauder, New Zealand	279	261	260	271	297	338	325	354	346	357	328	301
MLO	248	252	267	283	287	279	270	271	263	251	239	232
Nashville, Tennessee	298	289	319	[282]	–	338	316	311	291	291	273	269
Perth, Australia	268	258	265	267	278	272	293	301	327	331	–	[289]
SPO	265	233	–	–	214	223	249	–	–	139	168	238
Haute Provence, France	332	325	331	365	342	333	322	[298]	315	278	286	286
Marcapomacocha, Peru	249	[250]	[246]	252	[246]	–	–	–	–	–	–	–
BRW	–	[358]	423	407	403	340	316	292	–	–	–	–
Hanford, California	305	326	314	343	315	304	304	293	278	271	264	287

Monthly mean ozone values in square brackets are derived from observations made on fewer than 10 days per month.
–, no data; #, data are too sparse for meaningful monthly averages.

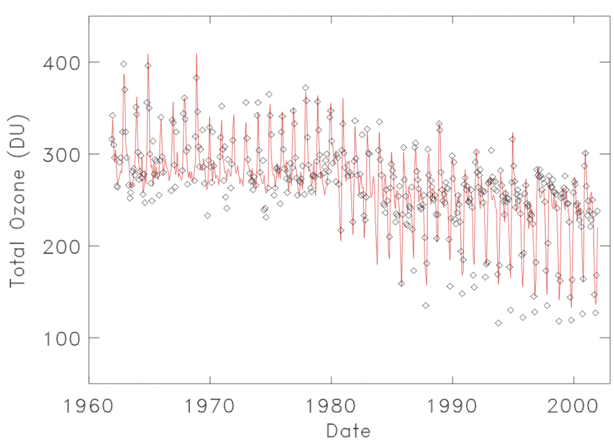

Fig. 4.1. Monthly mean (◇) and model (solid line) total ozone at SPO. The model accounts for the seasonal, quasi-biennial, solar, and detrended temperature dependencies in the data.

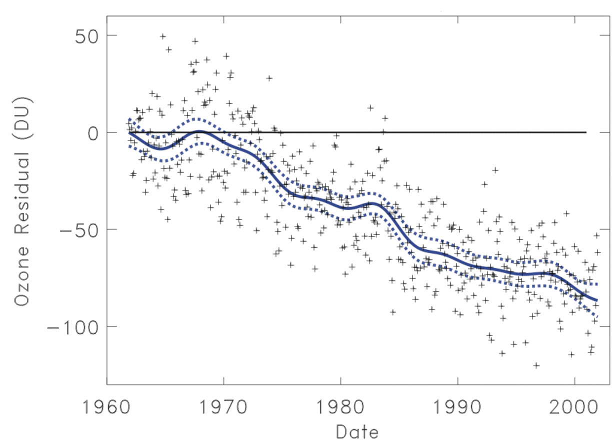

Fig. 4.2. Ozone residuals (+) at SPO after removal of known variations, and the tendency curve (solid curve) found from the filtering of the residuals. The dashed curves show the 95% confidence limits about each point on the curve.

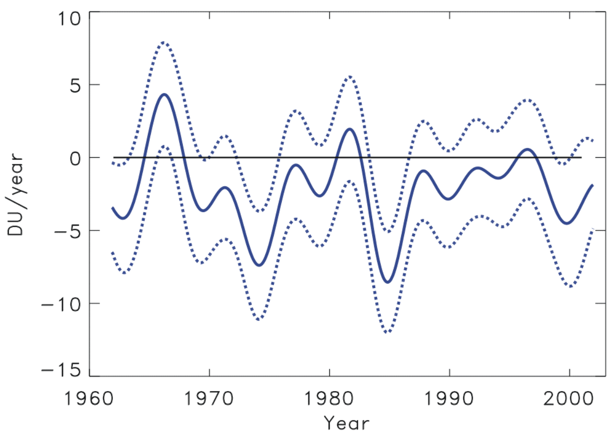

Fig. 4.3. Instantaneous growth rate of total column ozone (solid curve) at SPO, found by differentiation of the tendency curve shown in Figure 4.2. The dashed curves show the 95% confidence limits estimated with a bootstrap method.